Work, Energy and Power

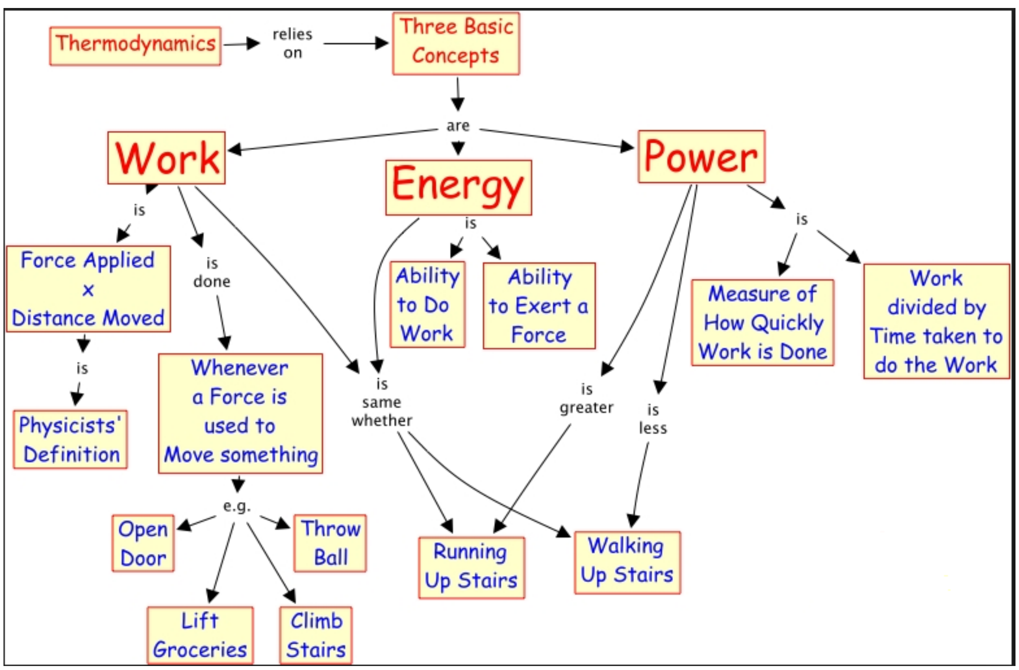
The term **work** was introduced in 1826 by the French mathematician Gaspard-Gustave Coriolis as "weight lifted through a height", which is based on the use of early steam engines to lift buckets of water out of flooded ore mines.

Work refers to an activity involving a force and movement in the direction of the force. A force of 20 Newton's pushing an object 5 meters in the direction of the force does 100 joules of work.

Energy is the capacity for doing work. You must have energy to accomplish work - it is like the "currency" for performing work. To do 100 joules of work, you must expend 100 joules of energy.

Power is the rate of doing work or the rate of using energy, which are numerically the same. If you do 100 joules of work in one second (using 100 joules of energy), the power is 100 watts.

The following diagram explains the practical example and concepts of work, energy and power.

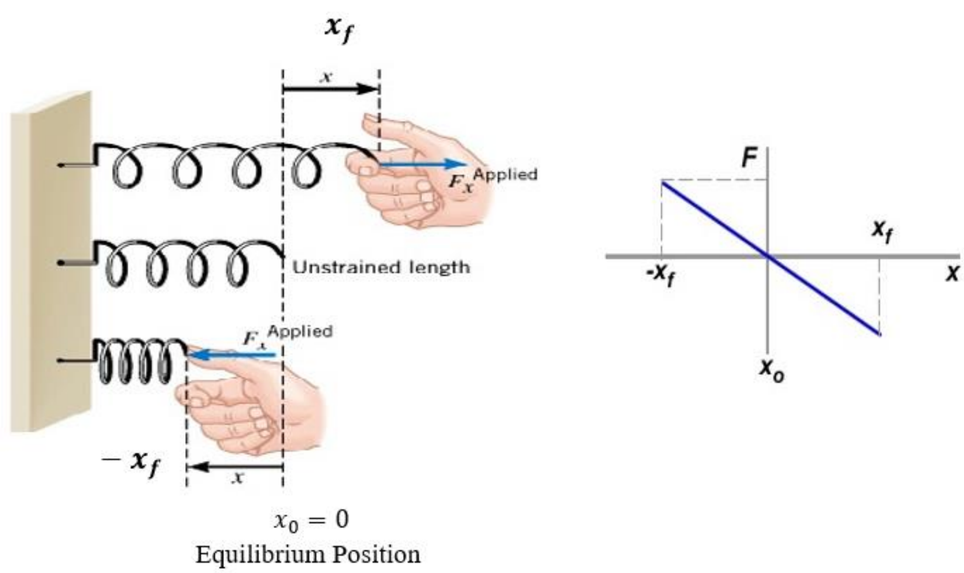


Work

If force is applied on an object and if there is a displacement of the object, then the product of the force and the component of displacement along the direction of force is called work.

$F = -k\,x$

Here, k is a constant. This is called spring constant. (Since, restoring force is against the displacement, negative sign is introduced.)



In order to expand the spring, equal amount of external force is to be applied in the spring. Let F be the applied force,

$$F_{applied} = F_{restoring}$$

$$F = -(-k\,x)$$

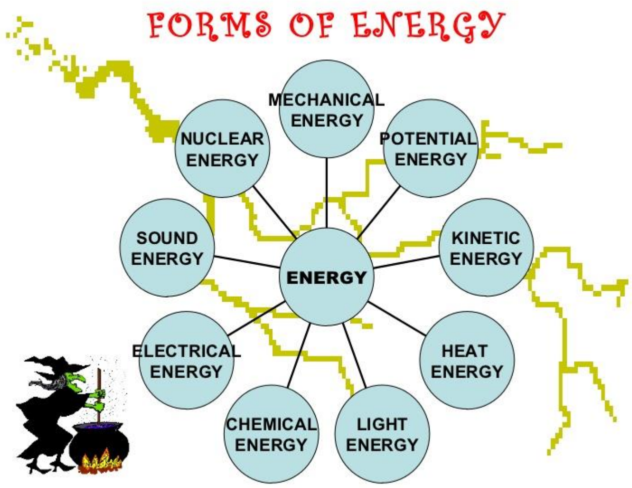
$$F = k\,x \ldots\ldots\ldots\ldots\ldots(1)$$

In expanding the spring from position x_0 to x_f , work done is given by

$$W = \int_{x_0}^{x_f} \vec{F} . d\vec{x}$$

$$W = \int_{x_0}^{x_f} F\,dx$$

$$W = \int_{x_0}^{x_f} kx\,dx \qquad \because \text{From equation number (1)}$$

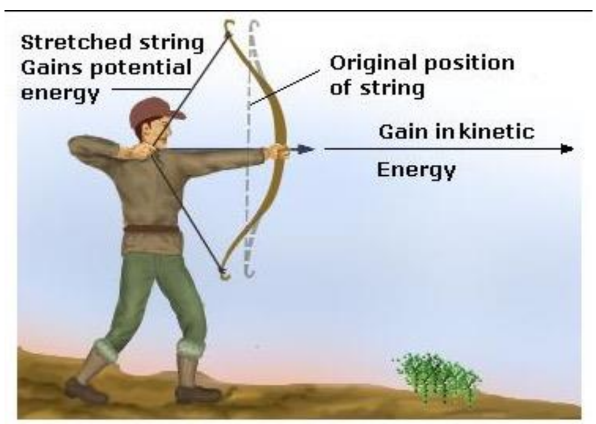


Potential Energy

In physics, potential energy is the energy that an object has due to its position in a force field.

Common types include the gravitational potential energy of an object that depends on its mass and its distance from the center of mass of another object, the elastic potential energy of an extended spring, and the electric potential energy of an electric charge in an electric field.

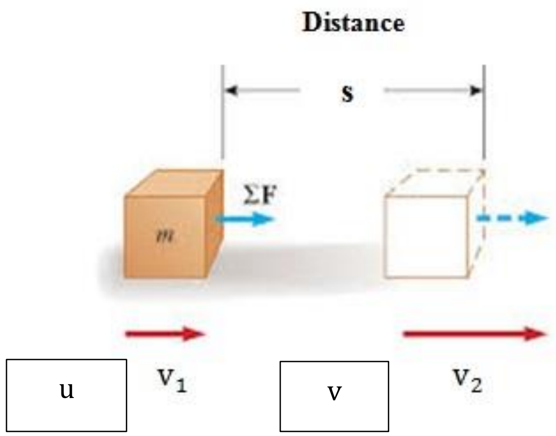
The unit for energy in the International System of Units (SI) is the joule, which has the symbol J.



Gravitational Potential Energy

On Earth, we always have the force of gravity acting on us. When we're above the Earth's surface we have potential (stored) energy. This is called gravitational potential energy.

$$s = \frac{v^2 - u^2}{2a} \ldots\ldots\ldots\ldots\ldots..(1)$$



So, the work done by the force

$$W = F.s$$

$$W = ma \times \frac{v^2 - u^2}{2a}$$

$$W = \frac{1}{2}\, m\, (v^2 - u^2)$$

$$W = \frac{1}{2}\, m\, v^2 - \frac{1}{2}\, m\, u^2$$

Work done $=$ Final kinetic energy $-$ Initial kinetic energy

$=$ Increase in kinetic energy

Hence, change in kinetic energy of an object is equal to the net work done by the applied force. It is the work - energy theorem.

Measurement of Kinetic Energy

- **In Case of Translational Energy**

According to the work-energy theorem

Change in kinteic energy $=$ Work done